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WOOD UTILIZATION IN PUERTO RICO

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Summary

The Puerto Rico Development Company is investigating opportunities for the expansion of local industries to ease unemployment and improve the economic situation in Puerto Rico. The possibility of expanding local production of furniture appears to be very promising if supplies of raw material can be obtained from dependable sources and at reasonable prices. The local forests contain only a small amount of merchantable timber suited for furniture and the trees are found scattered through rough country where extraction costs are high. Though some local timber will be marketed it will be only a small part of that needed by the industry and the bulk of the requirements will have to be imported.

The Dominican Republic now supplies a small part of the mahogany used in Puerto Rico but the supply from that country could be very materially increased. Cuba, which supplies the bulk of the mahogany used in Puerto Rico, was not investigated. A source of less expensive lumber must be obtained, however, to supply the market for inexpensive furniture. Presumably this supply can be obtained in the United States but other sources should also be investigated.

Cooperative buying through a central purchasing agency under the control of the Puerto Rico Development Company would be advantageous to the industry. Working through a central supply and distributing yard, logs and squares could be cut up in a sawmill, all lumber produced in the sawmill or imported could be properly seasoned in dry kilns and dimension stock produced as needed.

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Introduction and Object

Agriculture has in the past been the principal source of livelihood for Puerto Ricans, but the extent of land now suitable for agriculture is limited and insufficient to maintain the present and rapidly expanding population. Moreover, instead of growing food products, specialty crops are grown for export so that home grown food must be supplemented by a material amount of imported food products. Lacking extensive natural resources of other types, raw and finished products of all kinds must also be imported. The expansion of industrial operations that can absorb unemployment and, at the same time, reduce imports of manufactured merchandise and possibly produce some products for export, offers a very effective means of solving or reducing the existing economic problem. Some progress has been accomplished along these lines under governmental encouragement and direction, first by the Puero Rico Reconstruction Administration, and later by the Puerto Rico Development Company. The Puero Rico Reconstruction Administration sponsored the development of the Puerto Rico Cement Corporation, the Puerto Rico Ceramics Tile Factory, and the Fruit and Vegetable Cannery, while the Puerto Rico Development Company has established a large glass factory, now nearing completion, and has other projects under development. Among the latter is one that aims at increasing the local production of furniture, principally for domestic requirements but which may include some specialty items for export. The Puerto Rico Development Company requested the assistance of the U. S. Forest Service in determining the various factors affecting such a project, particularly the possible sources of material, both local and imported, amounts available, and the technical problems involved in logging, milling, seasoning, and merchandizing logs and lumber. While time and other obligations did not permit an intensive and complete examination of all conditions, it was possible to make a physical and economic study of the forest resources of

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Puerto Rico,[3] and to investigate the possibilities of importing raw materials from the Republic of Santo Domingo and Haiti.

Though the study here reported was strictly reconnaissance in character, it was sufficiently complete to supply the information needed for the constructive planning of ways and means to increase the local production of furniture. Additional information outside of the direct purpose of the study is included regarding the importance of the forests of Puerto Rico to the economy of the island that may have some bearing on future planning and forest management.

The authors gratefully acknowledge the effective aid obtained from various officials and individuals interviewed, too numerous to list here, but particular mention is made of the unselfish assistance and guidance of Arthur Upson, Director, and Frank Wadsworth, Associate Forester, of the Tropical Forestry Unit, and for the effective cooperation and courtesies of A. J. Dornbush of the Puerto Rico Development Corporation, Robert J. McArdle, of the Foreign Economic Administration in the Republic of Santo Domingo, L. R. Holdridge, Manager of the Forestry Division, Societe Haitiano -- Americaine de Developpement Agricole, Haiti, and the officials of the United States Embassies in Puerto Rico, Santo Domingo, and Haiti.

Commercial Importance of the Forests

It is difficult to comprehend a forest that is important for its yield of wood yet does not produce trees of timber size or even of pulpwood size. Forest trees of timber quality that once grew in Puerto Rico have mostly disappeared and the few that are left are largely in almost inaccessible locations where extraction is difficult and expensive. Large areas can be better described as brush lands than forest. Nevertheless the forests, woodland pastures, coffee plantations, and even mangrove swamps of Puerto Rico are of immense value because of the fuel they provide. There are no coal mines or oil deposits on the island and the electric power available or that could be developed would not supply the domestic fuel requirements. Coal and oil are, of course, imported for industrial fuel, bagasse is used by the sugar centrals and some oil and other fuels are used for domestic purposes.

However, the areas classed as forests furnish approximately 600,000 cords of wood which at a conservative retail value of $15.00 per cord, equivalent to the selling price of charcoal and presumed price of equivalent imported fuel, are worth $9,000,000. The shade trees grown in coffee plantations, the woodland pastures, and the trimming and salvage derived from the roadside and shade trees yield about 500,000 cords, equal to $7,500,000 per year. The average annual value of all exports from the

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[3] The data in this report on Puerto Rico apply only to the main island and exclude Mona, Vieques, Culebra, and other smaller nearby islands which have little or no timber, population, or industry.

island are about $100,000,000 and this amount is about equaled by the imports. The value of the fuel obtained from the forests alone thus represents about 9 percent of the value of all imports. Wood fuel from other sources raises the total to about 16.5 percent. These figures gain in importance when considering what economic problems would arise if all, or a major part, of the fuel had to be imported. Moreover, the labor involved in producing charcoal alone provides approximately 1,400,000 man days of work per year.

The forests also furnish most of the material used in the construction of ox carts and ox yokes, saddles and pack saddles, tobacco sticks, tool and broom handles, a large portion of the fence posts, some ties and poles, and an important proportion of the house posts, joists, rafters, and other parts of rural houses, all of material cut from small trees below commercial saw timbers in size. Such material represents a saving of approximately $150,000 in the value imports.

Even the few trees of saw timber size do yield a volume of saw logs and lumber that in the aggregate totals the equivalent of $400,000 worth of imported lumber, most of which goes into furniture, and construction.

Estimates, however, indicate that the forest drain is about 30 percent greater than the growth and may be expected to increase as the population increases. Nearly 95 percent of this drain is for firewood. Under good management, wooded areas are producing a growth of 3 cords of firewood per acre per year while the average production from all wood producing areas is less than a cord per acre and, as previously stated, most of the areas are being overcut. The importance of greater production from all types of wooded areas is obvious and suitable steps should be taken to increase the volume of wood grown per acre to prevent future shortage. The acreage of forests and woodlands can hardly be expanded on this compact little island where there is only 1 acre per capita, but the growth per acre can be increased.

Forest Resources

Forest Lands

The total land area of Puerto Rico is approximately 2 million acres, or about 1 acre of land per capita.

There are several sets of statistics on the forest areas of Puerto Rico. The following table of forest land is based on information furnished by the Tropical Forest Experiment Station, Rio Piedras, Puerto Rico. The figures, which are based on the 1940 census, are as follows:

	Acres
Insular forests	43,305
Federal forests	31,499
Privately owned	128,112
Coffee plantations	175,890
Woodland pastures	148,587
Total	527,393

The foregoing areas do not include shade trees, trees along fence rows and highways, and probably do not include some of the brush areas. If another 90,000 acres are added to the above figures to compensate for such areas, the grand total becomes about 620,000 acres. Shade trees, trees along the highways and railroad right-of-way, and some of the brush areas are important fuel-producing areas. Rose apple (Eugenia jambos L.) is a good example. This species does not ordinarily grow to be more than 35 feet tall, but some of the heavier stands on the best sites are reported to yield 500 sacks of charcoal per acre when 8 years old. This is equivalent to about 25 cords per acre, or a growth of a little over 3 cords per acre per year. Brush areas of this character, ordinarily unnoticed by the average forester, are probably of greater economic importance to the people of Puerto Rico than the stands of yellow pine in the South are to the citizens of the United States.

Forest Volume

No reliable inventory of the forest resources of Puerto Rico has ever been taken. In the preparation of this report less than 2 weeks were spent on actual field work. This short period of time is insufficient to make any reliable estimate of the forest volume. Therefore, the figures given here are based on observation, supplemented by experience in forest inventory work, and information obtained from the local Forest Service organization.

The Federal Forest Service cruised 17,802 acres on the Caribbean National Forest a few years ago. This cruise showed a total board-foot volume of 23,972,000. Of this amount, 18,568,000 board feet were found in trees greater than 10 inches in diameter. The total volume is less than 2,000 board feet per acre, but if based on trees greater than 10 inches in diameter, it is only a little over 1,000 board feet per acre. Tabonuco (Dacryodes excelsa Vahl.) showed more volume than any other species and makes up approximately 20 percent of the total. A study was made of the timber resources of Puerto Rico in 1911 and 1912 and a report was published on this investigation in 1916. The report issued that year showed a total forest area of about 600,000 acres, which included the brush areas. The area of forest land, as reported at that time, was almost the same as the present areas of such lands. The board-foot volume was estimated to be 27,500,000 board feet, and the total cordwood volume, including that on brush areas, was estimated at 2,487,000 cords. It was estimated at that time that if the then present rate of cutting were continued for a period of 16 years all of the forest resources would be completely exhausted. This survey was made some 33 years ago and since that date the population has nearly doubled.

The consumption of native wood products, particularly fuel wood, is much greater now than it was in 1912, yet there is still a considerable volume of wood left on the island of Puerto Rico. It is evident that the estimate of volume, growth, and drain was far too low, particularly the volume and growth. Probably the most logical explanation of why the volume estimate was far too low is that the standards of inventory were not in

line with the standards of utilization. There is probably no country where utilization is more intensive than in portions of Puerto Rico. Even small limbs and branches blown off of shade trees by strong winds are carefully picked up and utilized as though they were so much gold. The great economic importance of the forest resources of Puerto Rico to the low-income group, which represents a great preponderance of the entire population, cannot be emphasized too strongly. If there is any place where scientific forest management, good cutting practices, and bringing the forest lands into a state of maximum production is justified, it is Puerto Rico.

The present wood volume is estimated as follows:

	Board feet	Cords
Sawlog volume in trees over 10 inches.....	150,000,000 or	300,000
Cordwood volume including brush areas and scattered trees....	.....	15,000,000
Total.....		15,300,000

The above estimate includes all material down to the minimum sizes utilized. In many cases this will include material of 1/2 inch or less in diameter. The estimate includes, in addition to the volume on strictly forest lands, the volume of scattered trees on farms, scattered trees along fence rows and in pastures, trees along highways and railroads, shade trees, and all brush areas. This estimate is many times greater than the estimate made 33 years ago, but it is still short of meeting the requirements of the local people, except for charcoal and fuel wood. Practically the entire requirements for fuel, such as charcoal and cordwood, are obtained from the forests and scattered trees of Puerto Rico.

It is urged that a complete inventory be made of the forest resources of Puerto Rico and also that a detailed study be made of all wood requirements. It is realized, of course, that the estimate of the total wood volume which is given here is largely a guess, but it is believed to be more nearly correct than any past guesses. Ordinarily an inventory of forest resources is expressed in terms of cubic feet but it would be somewhat difficult in this case to express the volume in that unit of measure because, due to the small size material utilized for fuel wood, much of it is 30 percent or more bark.

It is pointed out that the estimate of the board-foot volume as given here includes a lot of low-quality logs and species that now have no commercial value for lumber. Local woods, which are considered desirable for furniture, such as guaraguao (Guarea trichilioides L.), cedro (Cedrela odorata L.), laurel sabino (Magnolia splendens Urban), and jaguilla (Magnolia portoricensis Bello), comprise a comparatively small percentage of the total board-foot volume.

Forest Growth

There is no reliable information available on the rate of growth of the Puerto Rican forests. The hardwoods on this island do not have annual rings and for that reason the rate of growth cannot be determined by use of an increment borer. Growth can be determined only by repeated reliable inventories of given areas or the establishment of permanent sample plots. The Federal Forest Experiment Station has already established a few permanent sample plots, but these plots are only about 18 months old, which is too short a period of time to give any reliable information on growth. The figures given here are, of course, largely a guess, but a rough estimate of growth is as follows:

	Cords
Board-foot growth in trees of sawlog size, regardless of species, 3,000,000 or.....	6,000
All other tree growth, including brush areas and scattered trees.....	800,000
Total.....	806,000

It should be pointed out that only a small portion of the total board-foot growth given above is represented by high-quality material or species considered desirable for the manufacture of furniture.

The growth estimate also includes low-quality logs and species which have no value as lumber at the present time. This estimate of growth is far in excess of any estimates that have been made in the past, but it is still considerably short of the estimated annual drain. If the estimates are correct, the annual drain is about 30 percent in excess of annual growth. The drain on the higher quality woods is many times as great as the growth, but how much greater would be difficult to guess. It is believed that the privately owned forests are being overcut and the better quality species are being seriously overcut. A thorough investigation should be made as early as possible of the rate of growth and drain of both public and privately owned forests.

Forest Drain

There is no reliable information available on the total forest drain, because no complete survey has ever been made. By far the heaviest drain on the forest is for charcoal and fuel wood. This is many times the drain of all other products. The total drain represented by charcoal and fuel wood was approached from three different angles as follows:

1. By interviewing well informed people in San Juan; also representative users of charcoal and wood, both in rural and urban areas.

2. By interviewing forest officers and loggers and obtaining from them an estimate of the percentage of families in both urban and rural

areas that use charcoal and wood; also, an estimate of the amount used per family per month.

3. By analyzing the report made by I. W. Jacobs, of the Insular Department of Labor.

The purpose of Mr. Jacob's survey was to determine the cost of living which made it necessary for him to collect information regarding charcoal and fuel wood. The sampling was mechanical and the families investigated were chosen from an aerial photograph of the entire island showing all the houses. A total of 5,000 families were investigated. The total amount of wood used for fuel, as determined by the three separate estimates, checked remarkably close and in each case amounted to a little more than 1 million cords per year. The following table shows our estimate of total drain:

	Board feet
Construction material (rough).....	300,000
Millwork items.....	50,000
Furniture.....	1,000,000
Carts, ox yokes, hewn ties, wagon tongues, house posts, etc.	760,000
Total.....	2,110,000

The board-foot volume given above, if converted into cords, would amount to about 4,200 cords. The estimated amount of charcoal used varies from about 6 to 8 million sacks per year. The estimated amount of fuel wood used also varies, but as stated above the total estimated wood volume used for fuel as determined from the three different approaches checked as close as could be expected.

The following tabulation presents a summary of forest drain:

	Cords
Lumber, 2,110,000 board feet or about.....	4,200
Charcoal, 8,000,000 sacks or.....	400,000
Fuel wood.....	700,000
Tobacco sticks, piling, fence posts, small poles for house construction, etc.	3,000
Total.....	1,107,200

The above figures do not include the fuel imported, the fuel obtained from salvaged imported lumber, or that which comes from coconut trees, palm leaves, etc. These sources of fuel do not represent a drain on the forests. If the volume of fuel obtained from these sources is added to the drain as given above, the total material used for fuel would probably be equivalent to approximately 1,200,000 cords per year. It should be pointed out that a considerable portion of the fuel drain comes from stems, trees, and portions of trees that are not ordinarily, if ever, included in any forest inventory. This probably explains to some extent the wide difference between the above estimate and former estimates.

Logging Methods and Cost

Accessibility

There is already a fairly good system of hard surfaced roads on the island, but a considerable portion of the timber on the Insular Forest and Federal Forest is still inaccessible because of the lack of roads and trails. Roads and trails should be constructed to the extent of whatever is necessary to make every acre of forest land reasonably accessible.

The Tropical Forest Experiment Station has done a remarkable job in increasing timber sales and introducing light selective cutting and scientific thinning operations for charcoal and fuel wood. The Federal Forest is capable of yielding considerably more volume than its present drain, provided that additional roads and trails are constructed so that the entire area could be brought under scientific management at the earliest practical date. The sawlog volume that could be cut from the Federal Forest, based on light selection is probably not more than 1/2 million feet per year.

Topography

A large portion of the timbered area is steep and rough. It is largely of volcanic formation which makes trail and road construction very expensive. It will require considerable investigation by a competent logging engineer in order to determine the most efficient plan of road and trail development for the Federal Forest. Every acre of commercial forest land on this forest should be made accessible to practical operation, in order that maximum growth and maximum benefits to the local people can be realized. The construction of such roads and trails would be a wise long-time investment, but could not be amortized by the present wood volume.

Methods of Operation and Cost

The present methods of operation might be described as the most primitive conceivable. Whipsawing is the prevailing method of operation. Trees are felled and bucked into log lengths, then the logs are squared up with an ax. The material is taken out to hard surface roads in the form of cants, planks, or lumber. Small logs may be taken out as cants, but the larger logs are generally whipsawed into planks or boards and then dragged out to hard surface roads with oxen. It probably requires more man days to produce 1,000 feet of lumber or plank in Puerto Rico under present methods of operation than it does man hours to produce 1,000 feet in the United States. A natural conclusion, therefore, would be that the method of operation should be changed and more efficient methods introduced.

Officials of the Puerto Rico Development Company, in looking for sources of cheaper raw material, were desirous of ascertaining whether or not there was a sufficient volume of high-grade hardwoods on the Insular

and Federal Forest to justify the purchase of equipment, such as tractors, bulldozers, trucks, and the construction of a modern sawmill, dry kiln, etc. located at some logical central point. Logs would then be transported by truck to the sawmill, manufactured into lumber, and properly kiln dried. Without making a careful analysis of the situation, it would be natural to conclude that this could be done and thus reduce the cost of producing the raw material to a point where the low-income group could afford to buy the furniture made from the high-quality native woods.

After carefully looking over some of the representative timbered areas, however, the conclusion is reached that such an undertaking would be impractical. The volume of timber per acre in federal forest areas if cut on a light selective basis is not sufficient to justify any type of power logging. The country is very rough and the trees marked for cutting under present management policies are too scattered to justify tractor logging. If a clean cut were permitted, it would then be practical in many cases to do power skidding which would greatly reduce the operating cost. If a clean cut were permitted in the heavier stands, modern methods of operation would be much more efficient than present methods. It is also believed that the stands on privately owned forests are too light and scattered to permit economical power extraction. The only reliable figures on the cost of operation by the use of tractors, bulldozers, trucks, and a sawmill were those obtained from the Army operation representing a period from July 1943 to April 1944. During this period they logged a little over 1/2 million feet of tabonuco. It is understood that one of the more intelligent local loggers had charge of the operation. The cost of operation, exclusive of any stumpage payments, was as follows:

Logging.....	$ 82.99 per M
Milling.....	37.12 per M
Total.....	$120.11 per M

This operation was in one of the heaviest stands on the Federal Forest and the operating conditions, so far as topography is concerned, were about average.

At present a gang of whipsawers are operating on this area under similar or more difficult operating conditions and the cost per M is reported to be considerably less than it cost the Army with modern equipment. These local operators were paying $25.00 per M for the stumpage and delivering the material on the hard surface road for $100 to $140 per M, depending on whether or not it was cut into planks or 1-inch boards. The whipsawing in this case was done at the stump. The local operators are very skillful in this method of sawing, turning out a well manufactured product. They are reported to earn from $2.50 to $3.00 per day, which is far above the prevailing wages for that territory.

Lumbering and fuel wood operations are conducted by local people who live in the forest or on nearby farms and the labor is estimated to involve more than 3 million man days of employment per year.

There is not a sufficient volume of good sawlog material concentrated in any one locality in Puerto Rico to make the use of modern logging equipment as economical as the present more primitive logging methods nor to justify a sawmill as a woods operation. The methods of operation are believed to be the most economical for the present or until the volume of timber per acre is built up to a point where more modern methods would become the most efficient. No place could be selected for a central sawmill location that would not involve a long and expensive log haul for an important part of the cut since the trees are so scattered. However if a sawmill were set up near San Juan for cutting imported material, it could serve for sawing domestic stock procured in the nearby forest areas.

Timber Requirements -- Present and Future

Though the island has approximately 25 percent of its area in forests or woodlands of one kind or another, the available timber is wholly inadequate to supply the needs for wood and wood products. Hence, a large volume of material both as rough and finished stock is now being imported. Nevertheless, the yield of wood obtained from the forests is of enormous importance to the island, particularly for fuel and agricultural uses and materially reduces the extent of imports that would otherwise be required. Records and data for accurate estimates of requirements are not available and the purpose here is to furnish what is primarily an analysis of the approximate consumption of wood both domestic and imported and suggest future trends in wood use.

Fuel Wood

Fuel wood represents one of the most important social and economic uses of the product of the local forests, woodlands, and mangrove swamps. Approximately 95 percent of the population is dependent upon locally grown material for domestic fuel, most of which is wood or charcoal. Some fuel is salvaged from coconut trees and nuts, palm leaves, and from waste of imported wood. A small volume of wood is also used as industrial fuel. A conservative estimate places the current consumption of local grown wood consumed as fuel either in the natural state or as charcoal, at 1,100,000 cords. The equivalent of 825 cords are imported as wood or charcoal. Salvage from all sources such as waste lumber, coconut husks, and palm leaves is estimated to be equivalent to about 100,000 cords making a grand total of about 1,200,000 cords.

This represents the equivalent of 0.6 cord per capita per year. Fuel is not required for domestic heating and is used principally for cooking and laundry work. It is used very sparingly both among the rural and urban population. Charcoal burners generally handle the charcoal in 40 pound sacks, but after delivery to the markets, it may be retailed in smaller packages of 5 and 10 pounds. The average amount of charcoal used per family in the low income brackets will be about one sack, or 40 pounds, per week, while in the neighboring Dominican Republic, a similar family would use about four times as much.

Lacking coal, oil, and other possible material for fuel, it seems certain that wood will continue to be the principal source of domestic fuel in the future and that the demand can be expected to increase in proportion to the population increase, and if living standards can be improved, the per capita consumption may increase also. Assuming a population increase of 2 percent per year, the total consumption of wood fuel can also be assumed on the same basis and would increase at least 20 percent in the next 10 years.

Agricultural Uses

The forests and woodlands furnish a major proportion of the material other than construction used on the small farms for fence posts, tobacco sticks, bee hives, and numerous other items, mostly produced from trees of small dimension. Some fence posts are imported. The total current annual consumption from material cut locally is estimated to be 3,000 cords.

Most of the material is used for repair and replacement since there have been very few new farms created in recent years. The practice of shifting cultivation on the steep hillside marginal lands naturally causes a shift of area and new demands for fence posts, but in general this is offset by other areas that are abandoned.

The project of resettlement of "agregados" on farm lands and "parceleros" in the forest areas will increase the demand for material used for agricultural purposes. Since the requirements are for new work rather than repair and replacement, the demands will be proportionately greater during the period of resettlement and may be estimated as an increase of about 50 percent above the present consumption during the next 6 years.

Industrial Requirements

Puerto Rico produces but a very small part of the lumber and timber used in the island, the great bulk of the requirements for this material being imported. Since the import figures vary with years of prosperity, depression and now because of the war, no satisfactory value for normal requirements can be determined. The per capita consumption during the fiscal year 1925-1926 was about 48.5 board feet. It dropped off during the depression years, but by 1939-1940, it was back to 48 board feet and in 1940-1941 was nearly 60 board feet. The per capita consumption in Puerto Rico seems to be very high for a country that produces about 1 board foot of lumber per capita and also in comparison with those countries having a Latin culture and where masonry is the predominant construction material.

Lacking more accurate values for normal requirements, the average consumption for the years 1939-1940 and 1940-1941 is used here to represent normal consumption and on this basis, the per capita consumption is estimated to be about 53 board feet. Shortages created since the war started

will, no doubt, mean a material increase in consumption for some years to come.

No satisfactory figures are available to represent the amount of lumber being produced from trees of timber size in the local forests. Estimates based on the best available data, place the current domestic lumber production at about 1,080,000 board feet from trees of saw timber size and an additional 1,030,000 board feet from smaller material, some used as hewn or round material in construction, some for ox carts, ties, and miscellaneous uses.

Construction

The construction field represents the largest single consumption item for lumber and timbers. Construction as used here includes not only housing, private and public buildings, but also such other construction projects involving the use of wood as dams, culverts, bridges, and port improvements. Figures available covering the importation of boards, planks, and scantlings, practically all of which is used in construction, indicate a fairly steady demand for such material from 1926 to 1938, except for the depression years when the demand dropped to about half of that in 1926. The average yearly imports for the fiscal years 1925-26, 1926-27, and 1927-28 were about 61,260 thousand board feet and for the fiscal years 1936-37, 1937-38, and 1938-39 were about 65,065 thousand board feet. The average for the intervening years was 47,565 thousand board feet per year. Assuming that construction was normal in the period 1925 to 1928 and proportional to building requirements of that period, it is evident that construction fell behind in the depression years and a material increase somewhat in proportion to population increase could be expected. Imports in 1939-40 were 84,087 thousand board feet and in 1940-41 they were 104,207 thousand board feet. After war was declared, imports of lumber for civilian requirements dropped off to a very small volume and construction work was limited to that pertaining to the war effort.

Because of the loss of normal construction during the depression and later during war years, it follows that a material increase in building will be necessary to catch up with requirements. A governmental planning board has prepared a project involving a very large construction program extending over a period of 6 years, financed in part by various tax supported agencies and in part by various public agencies which are wholly or partly self-financing. The program involves the expenditure of about $488,000,000 and includes administration buildings, schools, dams, drainage, airports, slum clearance and housing projects. Nearly half of the money will be used in types of construction where construction lumber will be required. A conservative estimate places the annual requirements at a minimum of five times the volume used in 1940-41 or about 500,000,000 board feet. There will also be a demand for lumber for private construction which will probably be at least half that of 1940-41 or about 50,000,000 board feet.

It is not anticipated that the amount of hewn and round stock cut locally for construction would be increased since this type of material is used principally in rural dwellings, tobacco sheds and similar buildings, where the yearly demand for new construction and repair work is fairly stable. It is assumed that material needed for new construction in connection with the resettlement of "agregados" will be largely imported and that used for buildings for "parceleros" will not materially exceed that normally used at present for similar construction.

Lumber for Factory Use

Factory lumber includes the wood consumed in making doors, windows, interior finish, boxes and crates, furniture, novelties, and various other wood products of miscellaneous character. The estimated consumption of lumber for the years 1939-40 and 1940-41 have been chosen to represent normal demand.

Sash and Door

Lumber used in the manufacture of doors, window sash frames, and interior finish is primarily factory lumber, but is ultimately used in construction and might well be added to construction lumber requirements. It has been separated here, however, for convenience in discussion. Approximately 3 million board feet of imported lumber is consumed in the local production of various shop made construction items. In addition, about $51,200 worth of such millwork is imported annually.

Any general increase in the building program as outlined under construction will, of course, apply to the production of millwork also. The present industry is probably tooled and equipped to handle a 50 percent increase in volume but could hardly be expected to absorb an increase of 500 percent without a material increase in both machinery and space. Under present conditions, certain items, such as inexpensive standard doors, can be imported and sold for less than doors made locally. If the building program contemplated involves enough standardized doors of this class, the use of special door making machinery might alter this situation, and permit local doors to compete with the imported product.

Furniture

Furniture manufactured in Puerto Rico normally consumes about 1,800,000 board feet annually, about 600,000 board feet of which is produced locally and the balance imported. In addition, nearly $1,000,000 worth of manufactured wood furniture is imported per year. The war has interfered with furniture imports and to some degree with furniture lumber imports, thus throwing normal demands out of balance with the supply and the local factories and dealers cannot supply the demand. Domestic production for furniture use has increased to about 1 million board feet per year to make up for part of the deficit of imported lumber. The locally produced

lumber is for the most part used in producing low priced furniture while the bulk of the imported furniture lumber is mahogany and cedro, used in high priced products.

If furniture production can be expanded to meet the potential market for normal demands, a material increase in imports of lumber will be necessary. Some will be mahogany and cedro for the better grades of furniture and some lower priced lumber for the competitive items. How the increase in imports can be divided between the two classes of stock can only be assumed at present. About 800,000 board feet of mahogany and cedro are now used in furniture annually and this amount might be increased to about 1,300,000 board feet. Approximately 400,000 board feet of other imported hardwoods were used in furniture in pre-war days supplemented by possibly 600,000 board feet of locally produced lumber. Importations of hardwoods of this class have almost ceased during the war and local hardwood production has been increased to supply the shortage. It may be assumed that when imports are resumed local production will fall off to possibly 600,000 board feet again but the imports of furniture hardwoods other than mahogany and cedro, may be increased to about 1,300,000 board feet annually.

If the furniture industry is expanded to absorb its proportion of the proposed construction project the total annual demand for normal and expanded requirements will be about three times that estimated above for mahogany and cedro or about 4 million board feet and about 5 million board feet for other hardwoods.

Boxes and Crates

Wooden boxes and crates are preferred for containers when shipping certain types of fruit and for bottled goods. Box and crating lumber used in Puerto Rico must be imported and the normal consumption of material imported as box shooks is 501,000 board feet plus nearly $125,000 worth of veneer shooks. It is estimated that about 500,000 board feet of imported lumber is also worked up in box and crating material. Export fruit and vegetable shipments are decreasing in some items, grapefruit for example, and increasing in others, and it is hard to predict a future demand for fruit and vegetable containers. Rum exports are very definitely increasing. With the completion of the glass plant the demand for bottle containers will increase. The canning plants will probably use fiberboard containers. In general, the future requirements for boxes and crates will probably remain nearly stable, possibly increase slightly.

Novelties

Puerto Rico, in common with other nearby islands, has a small, but well organized, wood novelty industry producing small woodenware articles for tourist trade and export. About 75,000 board feet of imported mahogany is used annually in this trade.

Other Miscellaneous Use

Oxcarts are made in small shops, largely by hand and mostly from material cut from small trees. Approximately 200,000 board feet of local material and 50,000 board feet of imported wood is used annually. Oxcart tongues use another 260,000 board feet of round material. Ox yokes, generally made by hand by forest workers, consume about 312,000 board feet per year. Automobile truck bodies consume about 100,000 feet per year.

Ties

Most of the ties used on the island are imported. Import figures place the normal annual requirements at 3,658,000 board feet. Some additional ties are produced locally, estimated to be about 200,000 board feet.

Poles

Poles for telephone and light wires are imported, the normal requirements being about 2,700 poles per year. The proposed construction program contemplates increased telephone and power lines and a material increase in the number of poles used can be expected.

Woodworking Industries that Could be Expanded

The depleted condition of the existing forests precludes any real opportunity for developing or expanding industries dependent upon a local supply of lumber. Hence any development or expansion of such industries must be accomplished through the use of imported raw materials. Labor is plentiful, however, and generally capable of being trained to suit the requirements of typical industrial projects. While it is doubtful if lumber products could be imported, manufactured, and re-exported to advantage, it should be possible to expand the existing woodworking industries to take up some part of the volume of imported manufactured wood products. The most promising opportunity for expansion to meet normal requirements would be in the production of locally manufactured furniture and a small increase might also be developed in millwork items. Both of these fields would be very greatly expanded if the proposed construction project materializes. Other fields of manufactured wood products are generally specialty items, have a relatively small market, and do not offer much promise of local development.

General Description of Furniture Industry

Furniture producers in Puerto Rico might be divided in three classes: (1) the small shop or cabinet maker having 2 to 10 employees, (2) the intermediate size shop having up to 50 employees, and (3) the larger factories having more than 50 employees. There are a great many of the small shops

and in the aggregate they furnish a fair percentage of the furniture made in the island. However, these shops have very little in the way of mechanical equipment and operate largely on a handicraft basis. In consequence, their output is more or less limited to the higher priced items, much of it custom made, where labor and material costs are less important than in the low and medium priced furniture. The intermediate sized shops are, of course, better equipped as to machinery and equipment but even these places lack adequate equipment and too high a percentage of hand labor is employed for economical operation. In the few factories having 50 or more employees, and where more machines are used, the principal output is generally some standard line of the lower priced items and where it is possible to take advantage of production line methods.

For the better lines of furniture, the preferred species is mahogany though some cedro is used. In the lower priced class domestic species such as guaraguao, jaguilla, and laurel sabino predominate. The smaller shops use mahogany and cedro almost exclusively, the intermediate sized shops may use some local species, while the larger plants in most cases depend upon local species and use very little imported wood. There are, of course, exceptions to these rather general industry descriptions.

Furniture buyers prefer furniture made of mahogany or cedro not only because of the appearance and beauty of the finished wood but also because of the natural resistance of these species to dry wood termites. Most of the other species used for furniture are less resistant to termite damage and shorter service life is expected of these species.

Though woodworkers understand that seasoned wood causes very little trouble and unseasoned wood will shrink after it is made up into a finished product, they do not know how to interpret this knowledge into more definite terms such as the percent of moisture present. As they do not know how to make accurate tests of moisture content, they have to depend upon judgment, experience, and the "feel" of the material in determining its suitability for use. Within certain limits dimensional change is more or less proportional to change in moisture content but the dimensional change is greater in some species than others for the same change in moisture content. Mahogany has a low shrinkage ratio compared to most of the other local hardwoods. Most of it is imported as sawn material and generally has been air-dried more or less before shipment and, in most cases, is used without further attention to seasoning. Some cedro is produced locally and some imported, but like mahogany, it has a low shrinkage ratio and presents no particular seasoning problem. Locally produced hardwoods are marketed more or less as fast as they are produced and without being seasoned. The buyer must assume the seasoning and this necessitates carrying stocks for a considerable period. The smaller operators find this impractical and generally use mahogany and cedro. The larger factories, however, can afford to carry stocks for air seasoning and some also finish the drying operation in dry kilns.

Lacking knowledge of how to test lumber properly for moisture content, it follows that material is often used which is inadequately seasoned and dimensional change after manufacture causes a certain amount of trouble.

This seems to be accepted as more or less inevitable by the producer and consumer and, of course, means that the acceptable standard for locally made furniture is lower than that in the United States where better seasoning practices are customary.

Markets for Furniture

There appears to be some question as to the ratio of imported furniture to that of the locally produced material. Opinion seems to vary widely, some feeling that as much as 80 percent of the furniture sold on the island is imported, others believing that less than 50 percent is imported. According to statistics, the value of imported furniture averages about $1,000,000 per year. No data could be obtained regarding the value of locally produced furniture, but on a basis of the amount of lumber used, a conservative estimate would be $2,000,000 to $2,500,000 per year. The imported furniture includes principally low priced competitive lines, but also includes some high priced household, office, and institutional furniture.

These figures, however, do not create a complete picture of the potential market. Furniture, particularly the low priced lines, is very high priced in relation to the income of the great mass of the population. A substantial reduction in price of the low priced furniture items would uncover a market only partly supplied at present. Through the use of better manufacturing methods, better machinery and lower priced lumber, it is conceivable that the cost of production could be decreased 20 to 25 percent. A proportional reduction in retail price might well increase sales in the low priced lines equal to a net increase of sales amounting to $800,000 to $1,000,000 per year, plus an increase in the intermediate price class of $500,000, amounting to a total of $3,300,000 to $4,000,000 for local made furniture. Part of this, possibly $600,000, would be taken away from the imported furniture.

There is approximately $600,000 worth of metal furniture imported annually as filing cases, office furniture, beds, and bed springs, and if furniture manufacturers made an effort to supply this market in wood products, it is quite possible they could capture at least one-third of the sales or $200,000 worth of additional business.

Materialization of the proposed 6-year building program, however, will expand the market for furniture, part of which will be special lines of hospital, school, and institutional types, part high class office furniture of all types that may have to be imported, but a large part of the demand can be produced locally. If furniture manufacturers are prepared to take on the part of this extra demand that can be produced locally, the volume should exceed the present local production by at least three times, or $6,000,000 to $7,400,000. If they can absorb part of the demand for file cases and other office furniture, it could well amount to another million dollars.

A small, but generally profitable, market for novelty or occasional furniture items could be developed for export to the United States. The volume of business can only be presumed, but it might well amount to $100,000 to $200,00 per year.

Recapitulation

Normal demand		
Local production	$ 2,000,000 to	$ 2,500,000
Imported	1,000,000	1,000,000
	$ 3,000,000	$ 3,500,000
Potential market for local products		
Local furniture market	3,300,000 to	4,000,000
To replace steel furniture	200,000	200,000
Novelty furniture for export	100,000	200,000
	3,600,000	4,400,000
Proposed construction project		
Household and office furniture	6,000,000	7,500,000
Replacing steel furniture	1,000,000	1,000,000
	7,000,000	8,500,000
Combined potential and project market	$10,600,000	$12,900,000
Reduction of normal imports		
Wood furniture	$600,000	
Steel furniture	200,000	
	$800,000	

Problems Affecting Expansion of the Furniture Industry

Production costs for all lines of furniture produced locally are comparatively high and if this industry is to be expanded, it must be done through reducing the cost of manufacture. Labor rates are comparatively low and are more likely to be increased than reduced. Production per labor hour is also low and could be very materially increased by the use of more machinery and better equipment. The cost of lumber used varies widely between species, but even the lowest priced material is very expensive. Furniture styles, in many cases, require stock of heavy dimension and solid wood is used where plywood could be used advantageously. Some shops make a more or less complete line of furniture instead of specializing on a limited number of items.

For economical production it has been found that furniture manufacturers can best be divided into specialty lines, one producer making chairs, another tables, and another bedroom furniture, and so on. By specializing, it is possible to have a full line of machines, labor saving devices and equipment, and highly trained personnel for a limited number of items. Naturally as the number of items made increases, the opportunity

for maximum efficiency decreases. For uniformity, the chair manufacturer makes chairs to match dining room tables produced by another manufacturer, and similar cooperative practice covers all other items. Within certain limits, this practice could be followed to advantage in Puerto Rico.

There is little prospect of much change in the cost of locally produced lumber as explained elsewhere. Cooperative buying of imported lumber does offer a real opportunity for economies and a regular and assured supply of properly seasoned material. Some changes in furniture design involving the use of plywood in place of solid wood and elimination of thick, heavy parts like turned bed posts, would save expensive material. Curved members could be produced by bending instead of cutting the part out of a single piece.

The gluing practice used is in general antiquated and manufacturers should adopt newer technics in gluing and assembly.

The problem of proper layout and arrangement, best machinery for each type of service, and general plant practice best suited to each class of product is a matter for consideration by experts in the design, layout, and operation of such plants.

General Description of the Millwork Industry

Almost all of the wood used for interior and exterior finish of all kinds is imported. Some items such as mouldings, standing trim, and flooring are manufactured before shipment. Even some sash, doors, blinds, store fixtures, and similar more completely manufactured mill products are imported. One large and comparatively well equipped mill manufactures a large proportion of the local production, the balance being rather widely distributed among a number of smaller plants and shops.

Cypress is the preferred species for exterior finish and blinds, but where price rules, longleaf pine and other species are used. Most of the upper grades are kiln dried by the lumber producer before shipment though some air-dried stock is also used. Because of the mild climate, glazed sash are often omitted but blinds on window openings are almost universal. On account of constant use combined with conditions favorable to decay, repairs and replacements of blinds are important factors in maintenance.

Somewhat less wood trim is used in the houses in Puerto Rico than in similar houses in the United States and a large proportion of the door and window trim, baseboard, and mouldings are imported as run moulding. Often cases and cabinets are built of lumber and mouldings rather than being prefabricated in a local shop. Ornamental ironwork replaces wood in many places, particularly in stair railings.

The mill equipment and machinery used is generally in keeping with similar small millwork plants in the United States handling a similar volume of business. In some cases, the machinery is very old and antiquated. The

local demand does not warrant the type of millwork plants, such as exist in the United States, specializing in one product such as doors, window sash and frames, or kitchen cases. This type of specialization as practiced in the United States generally means that the small mills cannot compete in price with the mass produced standard products and their output is more or less limited to those items not so highly standardized. Standard types of millwork are also imported into Puerto Rico where they can compete with or undersell locally made products.

Markets for Millwork

No figures are available regarding the normal production of locally produced millwork, but on a basis of the estimate of material used, the total value should be about $650,000 to $800,000 per year. In addition, there is about $50,000 worth of doors, sash, blinds, and other millwork imported per year. It is quite possible that the imports of standardized millwork items may increase at the expense of locally produced products. The methods of merchandizing millwork in the United States are changing so as to take advantage of mass production of standard items and leave the special work for the local millwork plant.

Should the proposed construction project materialize, the demand for millwork will be increased possibly six to eight times the normal demand. The existing plants can probably absorb about double the amount they now handle with the present equipment and space. Importation will largely depend upon the degree of standardization of items in the plans and specifications. If the plans are so prepared as to include a high degree of standardization permitting a maximum duplication of units and parts between buildings of different classes and types, it may well follow that better prices can be obtained on imported millwork. Less standardization would mean more local production.

Problems Affecting Expansion of the Millwork Industry

In keeping with the foregoing discussion, the opportunities for expansion within the millwork industry to meet normal demands appear to be limited. No appreciable expansion can be expected beyond that arising from population increase and from improved living standards. Most of the plants, however, are in need of new and improved machinery for economical operation.

The proposed construction project will probably alter the proportion of locally produced millwork compared to that imported. As organized and equipped at present, the local plants could probably double their volume of work leaving a volume estimated to be five to seven times that now produced to be obtained either by expansion or importation. Some expansion of present facilities would no doubt be justified, but a careful study should be made to determine how much expansion would be economically worth while.

Function of the Puerto Rico Development Company

Development and expansion of the furniture industry as outlined can hardly be expected to come from within the industry itself. However, it is the function of the Puerto Rico Development Company to promote such development and expansion, assist in financing through the agency of the Puerto Rico Development Bank, furnish technical guidance, and to set up an organization to supply raw material. Ways and means of financing have been developed and applied to other industries and need not be discussed here. Technical guidance involves many fields of skill such as design, instruction on use of machines, efficient plant layouts, good gluing practice, seasoning for use, and even in selling methods and markets. The Puerto Rico Development Company has started in this field in establishing the furniture pilot plant at San Juan. If the construction project develops, the Puerto Rico Development Company can help materially in organizing the domestic industries so that they can absorb as much as possible of the increase in demand for manufactured products. This would in some cases mean that Government agencies would be contacted and informed regarding the type and class of products that could be made in local factories. Such agencies would have to be assured that the quality of the product, materials used, workmanship, and deliveries would be satisfactory. The manufacturers would necessarily have to work in close cooperation with the Puerto Rico Development Company in order that this requirement could be met.

The Puerto Rico Development Company can also help manufacturers obtain an assured supply of the proper kinds of lumber, suitably graded and seasoned, and having the proper moisture content for use in Puerto Rico. Such a service could best be met by setting up a central supply yard at some suitable place and where adequate stocks would be maintained at all times.

Central Supply Yard

Cooperative buying of the imported lumber would, if handled by a well organized agency, have many advantages over the general system of individual buying as practiced at present. This agency, under the control of the Puerto Rico Development Company, could buy to better advantage, make better shipping arrangements, and deliver properly graded well manufactured seasoned material. Success of such an operation would depend upon the volume of business that can be handled. Estimates made show that the normal demand for mahogany and cedro for furniture production would total about 100,000 board feet per month. Such a volume is probably about the minimum that could be made to pay. The expanded construction program would increase this volume to about 333,000 board feet per month.

How other hardwood species, used principally in low priced furniture items, would be handled depends largely upon the source. If obtained from the United States, they could be shipped direct to the ultimate consumer or handled through organized lumber dealers about as advantageously as through

a cooperative central yard. However, if imported along with mahogany and cedro from Cuba, Santo Domingo, or other nearby places, it would probably be advantageous to handle the product through the central yard system. These factors can only be determined when a proper investigation has been made of sources of supply and costs of material under post-war conditions.

Most of the mahogany and cedro is now imported in the form of lumber and plank, but if satisfactory arrangements can be made with producers, a portion could be brought in as logs or squares. In fact, greater yields and utilization can be expected if the material is converted at the yard from logs into dimension stock.

To obtain the maximum benefit from a central supply yard, there should be:

1. A small, but efficient, sawmill to convert logs and squares.
2. Seasoning yards and storage sheds.
3. A planing mill and dimension stock plant.
4. Seasoning and conditioning rooms.
5. Supplies such as glue, hardware, plywood.

Site.--Such a yard should have water, rail and highway connections, the site should be reasonably level and on well drained ground high enough to be free from danger of floods. Ample space should be provided for free flow of incoming logs and lumber, seasoning yard, manufacturing and processing buildings. Ten acres would not be too much, but a smaller space could be used. Probably one of the best locations would be somewhere on the waterfront of the bay opposite San Juan.

Sawmill.--A suitable unit is needed to break down logs and heavy squares into cants and flitches that would be cut into boards on another saw. This head saw could be a circular mill comparable to a No. 3 American. For logs up to 28 inches in diameter, a 48-inch inserted tooth 9-gage saw should be used. For logs up to 36 inches diameter, a 60-inch inserted tooth 8-gage saw should be used. The 48-inch saw would take typical Cuban and Dominican logs.

Seasoning yard.--Mahogany lumber up to 1-1/2 inches in thickness should be end racked in the yard until air-dry. If stocks of air-dried material accumulated faster than required, it should be close piled in the shed until needed. Other species, more refractory than mahogany, should be piled in the sheds on stickers for air seasoning. Seasoning sheds should be open on the side with wide overhanging roofs. They should have a central runway for loading and unloading, and the pile foundations should be 18 inches above the ground on either side of the runway. Piles should be about 12 feet high and the roof should be high enough above the pile to permit easy loading and unloading. Piles of green lumber should be on nominal 1-inch by 2-inch stickers, with openings between boards of 2 or 3 inches in vertical alignment. Each bay should be 16 feet wide between posts with two 6-foot piles per bay. Each bay should hold an average of about 6,000 board feet of random length stock on stickers on either side of the runway or 12,000 board feet per 16 feet of shed length. Enough

space should be provided to carry at least 5 months' supply of stock in this shed. The shed capacity for mahogany should include piling space for the material over 1-1/2 inches thick for seasoning plus storage space for thinner material that had been dried in the yard. For the latter, which could be close piled, probably 32 feet of shed length would be sufficient. Assuming that 30,000 feet of other species would be cut in the sawmill per month, the shed should have capacity for at least 150,000 board feet equal to about 192 feet of shed length for this material. If the yard were to handle species imported from the United States, as air-dried or kiln-dried stock, the shed should have a storage capacity of about 100,000 board feet for normal requirements or 400,000 board feet for maximum requirements. Each 16-foot length of shed would hold about 30,000 feet of such stock and the required length could be determined on a basis of requirements. The shed capacity can only be determined when methods of operation are established and since methods may change, space should be available for expansion if necessary.

Processing plant.--To reduce sawkerf, the cants and flitches produced in the sawmill should be cut into lumber on a band resaw. For this service, a shop type vertical band resaw in the 5,000 to 7,000 pound class, having a 4-1/2- to 5-inch blade and 48-inch wheels, is recommended. This machine should be designed to take unedged stock and have adjustable rolls.

Other machines would be:

(1) A 2-saw edger, 14- or 16-inch saws to edge boards that are to be sold as lumber.
(2) A circular swing trim saw.
(3) A double surface planer 24-inch heavy duty type.
(4) A self-feed straight-line rip saw with feed rolls.
(5) For dimension stock cutting:

    (a) Cut-off saw, one for each 4,000 board feet of dimension stock cut per day.
    (b) Rip saw, can use the saw called for in No. 4.
    (c) Bundling machine and rack.

All machines should have individual electric motors for power. The material should be handled through the plant on hand buggies.

Seasoning and conditioning rooms.--One or more rooms should be provided for conditioning stock to the optimum moisture content for service. Space will be required for (1) drying air-dried stock to the required final moisture content, and (2) storage space for seasoned lumber and dimension stock awaiting delivery. The function, size, and methods of operation are discussed in appendix A.

Supplies.--The central yard can perform a useful service in keeping certain staple supplies for the subscribers. Among the items could be a special line of plywood made with mahogany faces and some termite resistant core stock, a supply of glue, particularly the cold-setting resin type, various kinds of stains and finishes, a line of furniture hardware, such as

drawer pulls, hinges, chair springs, bed springs, upholstering supplies, and drawer rollers for file cases.

Suggested Yard Layout

Actual yard plans can only be developed when the site has been determined, but a site of about 10 acres facing on a water frontage has been assumed for illustration purposes (see figure). Lumber arriving by boat can be unloaded on the dock or pier, logs can be unloaded on the pier or into the water. Material can also be brought in by rail or truck. Logs and heavy squares would go through the sawmill to be broken down into cants, then on to the resaw, while smaller squares and cants would by-pass the sawmill and go direct to the resaw.

Material intended for dimension stock should not be edged or trimmed, but if intended for square edged lumber, it should be edged and trimmed when necessary. The green stock should go to the yard or air-seasoning shed. Stock intended to be kiln-dried should be stacked on kiln trucks, and stored on trucks awaiting kiln space. Kiln-dried stock should be transferred on kiln trucks to the cut-up room, if intended for dimension stock or any other processing, but if not processed, should be unloaded from kiln trucks at the kilns.

Uneven thickness stock should pass through the planer. The planer would also serve to dress stock for subscribers who preferred dressed stock, and light planing is sometimes desired before stock is marked for cutting into dimension stock. The rip saw and cut-off saw would be used principally for producing dimension stock. Such stock should be bundled and stored in the heated storage room.

Two dry kilns are shown and space is provided for additional kilns if needed. A covered unloading shed is shown in front of the kilns. A transfer truck is provided to transfer green material from loading docks to the kiln trucks and to move dry stock from the kilns to the processing plant. It is assumed that the sawmill, processing plant, covered unloading shed, loading docks, and air-seasoning shed will have open sides, but the heated storage shed, tool room, and boiler room will be enclosed.

One air-seasoning shed is shown with room for an additional shed if needed. The size of these sheds must be determined on a basis of the volume of material they are expected to handle. Two areas are indicated for open yard air seasoning and one area for end racking mahogany.

For the two dry kilns and heated storage, a 75 horsepower low-pressure boiler is required. It is doubtful if sawmill and processing plant waste will furnish a steady and sufficient supply of fuel and as such waste has a reasonable market value, other fuels may be considered. Oil fuel would be advantageous in that it would mean a minimum of firing labor and attention. The following cost estimate is based on the assumption outlined and is of value only as a guide. The price for machines is

list price f.o.b. factory and subject to discounts, which may be enough to equal freight and handling costs.

Estimate of Cost of Central Supply Yard

Buildings, Machinery, and Ground Improvements

Buildings

Sawmill shed	$ 1,500
Planing mill	30,000
2 dry kilns and storage shed	14,000
Air-seasoning shed	30,000
Office and garage	15,000
Boiler house and 75 horsepower boiler	5,000
	$95,500

Machines

Sawmill and motor	$ 2,300
Band resaw	4,500
Edger	650
Pull trim saw	200
Planer	2,000
Rip saw	2,500
Cut-off saw	800
Bundling machine	200
File room tools	1,000
	$14,150

Yard

Dock or pier	$10,000
Roads	5,000
Fences	4,200
Transfer track and loading dock	1,500
Switch track	5,000
Foundation air-seasoning yard	1,000
Miscellaneous items, power line, water, etc.	5,000
	$31,700

Other equipment

2 auto trucks	$ 5,000
10 shop hand trucks	500
Miscellaneous items, blower system, accessories, etc.	5,000
	$10,500

Grand total	$151,850

The sawmill will handle about 8,000 to 10,000 board feet per day cutting short logs into cants. The resaw will cut an average of 30,000 board feet of 1-inch lumber per day. The dimension stock plant as outlined will process about 4,000 board feet of rough lumber per day. The dry kiln can turn out a maximum of about 108,000 board feet of 1-inch mahogany per month per kiln or about 72,000 board feet of more refractory species per month per kiln.

It is assumed that incoming material will be part logs, part squares, and part sawn lumber. Assuming 100,000 board feet per month arrives as logs or squares, the sawmill would operate about 10 to 12 days per month, the resaw about 4 days per month. The same crew could be used on both saws. The laborers in the crew could use the balance of their time in piling lumber, and the skilled men, on the production of dimension stock.

Personnel

There are certain key positions requiring thoroughly experienced men for proper and efficient operation of the yard and plant. The general manager would have to know how and when to buy the various kinds of logs and lumber, prices for the various grades of material, shipping and handling, yard management, and delivery problems. The production foreman would be in charge of the sawmill and all processing and would have to understand sawmill and dimension stock production. The dry kiln operator would have to be experienced in handling hardwoods through the air-drying and kiln-drying operation and since this should not be a full time requirement, he could also do the grading. These three key positions require men who have obtained their experience on reasonably large operations, and it is doubtful if they can be found in Puerto Rico. An experienced sawyer is desirable, but a local man can be trained to this position by a competent production foreman. Saw filing and tool maintenance also require a special type of skill and training. An experienced sawyer and saw filer might be employed temporarily to train local men in these two fields of work.

Lumber Prices

It would be futile to suggest probable prices for lumber after the war. Timber, like many other vital war materials, has been used lavishly, stocks are depleted, the remaining standing timber is less accessible and no doubt the general world demand for wood after the war will be very heavy. Commodity price control measures have held prices of some lumber items within bounds, but even in this field prices have advanced.

Prices for domestic lumber vary in different localities, but the prices quoted per 1,000 board feet by dealers ran about as follows for log run material delivered to the factory:

Species	Dollars
Tabonuco	250 to 350
Guaraguao	250 to 350
Cedro	250 to 500
Jaguilla	350 to 400
Laurel sabino	350 to 400
Copá prieto	350 to 400

One manufacturer had a small stock of tupelo gum #1C&S for which he had paid $120 per thousand.

Lumber dealers in the Dominican Republic expressed opposite opinions regarding post-war prices for mahogany. One dealer was selling 1-inch good and better mahogany f.o.b. San Juan in 1943 for $180 per thousand, and in late 1944 for $265 to $275 per thousand. He is now quoting $300 and expects the price to reach $350. Another dealer expressed the opinion that prices would drop off after the war to about $200. According to export statistics, the average value per thousand board feet of Dominican mahogany exported to Puerto Rico was as follows:

Year	Average value per M
1939	$ 75.50
1940	64.00
1941	60.00
1942	77.00
1943	155.00

Freight from Cindad Trujillo to San Juan is about $23.00 per thousand. There are a number of charges, presumably absorbed by the shipper, that naturally affect the ultimate price. There is an internal revenue tax of $30.00 per thousand, cutting permit $8.00, handling charges and wharfage $1.15 per thousand, a miscellaneous charge of $5.00, and a consular fee of $2.50 for the shipment.

The present price of cedro is about $20.00 per thousand less than mahogany.

Lumber prices in the United States may best be represented by the ceiling prices set up by the Office of Price Administration. The following table gives such prices for a limited number of the southern hardwood species used in the furniture trade. These prices were in effect during the spring, summer, and fall of 1944, but in the late winter of 1944-45, prices of some items were raised $3.00 per thousand. The prices are f.o.b. mill and subject to domestic freight, export fees, and shipping charges for delivery to San Juan. Freight from gulfports to San Juan was said to be about $18.00 per thousand.

U. S. A. Ceiling Prices -- 4/4 Stock -- f.o.b. Mill

Species	Sawed	F.A.S.	#1C&S	#2C
Red gum	plain	$ 98.00	$53.00	$40.00
Red gum	quartered	102.00	57.00	40.00
Sap gum	plain	62.00	48.00	34.00
Sap gum	quartered	66.00	52.00	36.00
Black gum	plain	56.00	46.00	34.00
Black gum	quartered	59.00	49.00	36.00
Tupelo	plain	56.00	46.00	34.00
Tupelo	quartered	59.00	49.00	36.00
Magnolia	-----	75.00	53.00	42.00
Red oak	plain	70.00	50.00	38.00
Red oak	quartered	71.00	48.00	38.00
Yellow-poplar	plain	72.00	59.00	49.00
Yellow-poplar	quartered	77.00	64.00	52.00
Sycamore	plain	53.00	43.00	29.00
Sycamore	quartered	59.00	49.00	41.00

Sources of Material

Before present restrictions on shipping developed, some hardwoods were imported from the United States for use in the low priced furniture items, but when this source was cut off, production of local hardwoods was increased to make up part of the deficit. Under post-war conditions, it is probable that the domestic production will decrease and that imports from the United States will be renewed. The class of stock represented is generally air-dried at the producing mill. Buyers sometimes specify that the stock be kiln dried in which case, the general practice is to kiln-dry air-dried stock. Air-dried stock imported into Puerto Rico requires further drying before being put into use. Kiln drying before shipment will not assure stock at the right moisture content since moisture pickup in handling and transit might mean redrying would be necessary.

Mahogany and cedro for the better grades of furniture and a limited amount of other hardwoods have been imported principally from Cuba with a small amount from the Dominican Republic. Shipping restrictions have also affected shipments from these sources and shortages have resulted in higher prices. Some material is cut by small circular sawmills and some is whip sawn in the woods. The stock is sold as lumber, plank, squares, and a limited amount in the log form. Lumber and plank may be air-dried or sold practically green. The mahogany trees are comparatively small and sometimes crooked and the lumber produced is sold in random lengths and widths. Lengths run from 4 to 16 feet averaging about 10 feet and widths from 6 to 20 inches, averaging about 10 inches. An attempt is made to grade the stock into selects, representing about 40 percent of the yield, good, representing about 35 percent of the yield, and common.

Some information was obtained regarding available supplies of mahogany in the Dominican Republic and Haiti which is given in some detail

in appendix B. Briefly, the Dominican Republic produces about 2 million board feet per year and exports about 250,000 board feet to Puerto Rico. The production could be doubled in the Dominican Republic and there is probably 20 years' supply in sight on that basis. There is no appreciable amount of mahogany available for export from Haiti, in fact Haiti is hard set to get enough for domestic requirements. The resources of Cuba were not investigated. Other possible sources for mahogany would be the Central and South American countries now supplying the world market. African mahogany might also be considered. War demands have, of course, dipped heavily into available sources everywhere. For example, the Foreign Commerce Weekly of January 20, 1945, says, "Commercial mahogany stands in British Honduras are now located in less accessible areas, at a distance from good rafting streams and for the most part in the interior. The wood is excellent in grade and size, but expensive to log. Existing stands of virgin mahogany are being rapidly cut and additional transportation facilities will be needed to maintain the colony's present position in the Central American mahogany industry."

There are, of course, a number of species other than mahogany and cedro in the Dominican Republic that make good furniture, some of which are being imported into Puerto Rico at the present time. Among these are baitoa, capá, caracoli, and roble. At pre-war lumber prices, these species could hardly compete with hardwoods from the United States, but under post-war conditions, these and similar species may supplant imports from the United States.

APPENDIX A

Seasoning Problems in Puerto Rico

In the process of converting a tree into lumber ready for commercial use, one important step is the removal of all excess moisture, this process being commonly referred to as "seasoning" the lumber. The quantity of water or sap in a living tree may have a weight that is one-third to three times the oven-dry weight of the wood. The moisture present in wood has an influence upon its strength and resistance to decay, dry wood being stronger than green wood and immune to organic stain and decay. Changes in moisture content cause changes in dimension, and it is well to have these dimensional changes take place before, rather than after, the lumber is made up into a finished article where the dimensional changes would affect its utility or value. In the seasoning process, considerable shrinkage takes place, and precautions must be taken to prevent unequal shrinkage stresses from causing defects such as warping, twisting, checking, splitting, and case hardening. The proper moisture content at the time the lumber is manufactured into a finished product is that which is best suited for the conditions to which the material will be subjected during manufacture and, later, during use. This moisture content may vary more or less depending upon the use, seasonal and geographical variations in temperature, humidity, and standard of quality demanded of the finished product.

Stock may be kiln dried as it comes from the saw or it may be air-dried in a yard or in sheds. The kiln drying of green material involves a number of problems to be discussed later. It is a practice commonly followed in large softwood mills in the United States, but generally uncommon at hardwood mills. Hardwoods are, as a rule, air-dried for several months at the producing mill. The moisture content of air-dried stock is, however, too high for many types of service, particularly for furniture, interior finish, flooring, and similar uses where the product is subject to low humidity conditions in service and such stock is invariably kiln dried before manufacture. Because of the low humidity conditions that prevail in northern United States during the winter when houses are heated, furniture stock must be dried to a low moisture content to give good service. In the Gulf States, where higher average humidities prevail, the optimum moisture content of furniture stock is higher. Where humidities are low in winter and high in summer more or less trouble naturally develops.

Fortunately the humidity conditions to which furniture and similar wood products are subjected in Puerto Rico are less variable and also generally higher than is common in the United States, a factor that, in part, simplifies the seasoning problem. In fact, it is possible to air-dry stock to a moisture content closely approaching that best suited for service and actually a major part of the local furniture produced is made of air-dried wood. Unfortunately, too many of the local manufacturers are not informed regarding methods of determining moisture content and depend upon judgment and "feel" to determine the condition of stock. As a result, insufficiently seasoned stock is often worked up into finished products.

Seasoning practice varies more or less in the different lumber producing centers and since Puerto Rico uses not only local materials, but that produced in several other areas, the product of each area must be considered separately. Local lumber is produced from logs whip sawn in the forest or extracted as squares or cants and sawn into lumber by the ultimate consumer. No effort is made to season whip sawn lumber before it is sold, hence the responsibility for seasoning in either case, falls on the consumer. The usual local practice is to stack stock in sheds, or sometimes in the open for several months to allow the stock to air season. The methods of stacking and piling, however, do not conform to well-known good practice.

Imported mahogany and other hardwoods from the nearby islands are usually air-dried more or less before shipment, but at the present time, the demand is brisk and the producers are shipping quantities of unseasoned material. As discussed elsewhere, it may be presumed that post-war demands will be heavy and that producers cannot be relied upon to thoroughly air-dry stock before shipment. Since hardwood stocks in the United States are also at a minimum and as post-war demands will be very brisk, thoroughly air-dried stock will be scarce and shipments are likely to contain material at a relatively high moisture content.

The terms "green," "shipping dry," "air-dry," and "kiln dried," although widely used, have no specific agreed meaning with respect to moisture content except in a few cases where lumber association rules define moisture limits for kiln-dried and air-dried stock. The only satisfactory method of defining the degree of seasoning attained in a given lot of lumber, is to express it in terms of moisture content. Wood, like other hygroscopic materials, will give off or take on moisture from the surrounding atmosphere until the moisture in the wood balances that of the atmosphere. At this time, it has reached what is called the equilibrium moisture content. For example, thoroughly air-dried stock stored in a shed in San Juan will have a moisture content of about 13 to 15 percent, while furniture in an average house would have a moisture content of about 10 to 11 percent.

Since both domestic and imported lumber may be expected to have a much higher moisture content than that best suited for most manufactured wood products, some method of further seasoning must be provided before it is used. It may be kiln dried from the green or partially air seasoned condition to any desired final moisture content. It may be air-dried in open piles in a yard or under cover in a shed. Since such air-dried stock has a moisture content somewhat higher than is desired for furniture and interior finish, some further drying is necessary. This may be done by storing the stock in a dry storage space for an extended period, or, more rapidly, in a heated storage room or dry kiln.

Air Seasoning Versus Kiln Drying

There are certain advantages in kiln drying stock green from the saw, and it is a practice followed by many lumber producers in the United States. It is most common in the southern pine and West Coast regions in

mills where large volumes of one species and thickness are produced. The species represented are conifers and may be seasoned very rapidly and with low degrade. A large part of the kiln dried products are immediately manufactured into finished products such as interior and exterior finish, sash, doors, flooring, etc. On the other hand, hardwoods are in general much more difficult to season than most of the conifers and require a much longer period in the kiln. This means that several times as much kiln space is required to dry a given amount of hardwood compared to an equal volume of conifers. Moreover, most hardwood forests contain mixed species that require separation since they cannot be economically dried together under the same drying schedule. A very large part of the hardwood output is cut by small sawmills of the semiportable type. Considering the relatively small daily output of such mills and delays involved in accumulating kiln charges of those species and thicknesses that can be dried together, combined with numerous other factors, such as lack of boiler capacity, investment required, and problem of moving the kilns when the mill is moved, kiln drying hardwoods green from the saw is hardly economical. Some of the larger hardwood mills with more permanent locations and large daily output do find it profitable to kiln dry certain species and grades from the green condition. Since hardwoods are so generally marketed as air-dried materials, the ultimate consumer is responsible for any further drying necessary for his product. In the case of furniture, for example, the stock in some cases must be dried to a moisture content of about 5 to 6 percent to meet service conditions. Dry kilns are invariably used for such purposes. Air-dried stock, when received, may have a moisture content of 17 percent or more and to dry it to 5 percent with a minimum of checking, splitting and honeycombing, requires skillful operation in a well designed dry kiln.

The seasoning problem in Puerto Rico is somewhat similar to that of the hardwood situation in the United States. Hardwoods imported from the United States or from nearby islands will be air-dried more or less. Stock produced locally will be green, but the volume will be small and hardly justify installing enough kiln capacity to dry it from the green condition. Hence, it seems advisable to provide means to thoroughly air-dry both imported and domestic material as the first step in seasoning.

Further drying before manufacture can be most effectively accomplished either in a dry kiln or in a heated conditioning room. The drying problem is materially simplified by the fact that the stock need only be dried to about 9 or 10 percent instead of the 5 or 6 percent necessary in the United States. In fact, thoroughly air-dried nonrefractory species like mahogany and cedro can be dried in a chamber or room where the temperature is maintained about 20° above outside temperature.

Suggestions for Air Seasoning Practice

Much study and experimentation has been applied to the problems of air seasoning in the United States, resulting in reducing degrade from checking, warping, stain, and decay, as well as decreasing the time required for seasoning. These improvements in the quality of the stock occur

where certain piling practices are followed that have been found to give the best results.

Piling that is correct for air seasoning must be of a type that provides suitable and proper air circulation, protection from the sun and rain, and must keep the boards straight and flat while drying.

In a properly laid out yard, adequate aisle space must be provided with the piles facing the aisle on either side. The piles should be about 6 feet wide and about 3 feet between piles. The pile foundations should be made of three stringers or girders, about 6 inches by 8 inches, and the same length as the depth of the pile, set on posts and sloping from the front to the rear about 1 inch per foot. Beams, 4 by 6 inches in size, should be laid across the stringers. The length of these beams is equal to the width of the pile. These beams should be two feet apart. All parts, stringers and beams should be of a strong durable species, and free from sapwood or decay. The foundation should be so laid out that there will be a minimum distance of 18 inches from the ground to the top of the beams at the rear of the pile if the yard is on level ground, and an average of 2 feet under the pile if the yard is on sloping ground.

The piles are erected by laying the boards over the foundation beams in only one direction starting with a sticker over the beams and separating each superimposed layer with stickers. The stickers should be made of thoroughly air-dried stock, free from stain or decay and of uniform thickness. They should be made from nominal 1-inch stock and about 2-1/2 inches wide and the same length as the width of the pile. Each tier of stickers should be aligned vertically as they are laid in place so as to be over a supporting beam of the foundation. Stickers at the ends of the pile should overlap the ends of the boards about 1 inch to reduce end checking. Stickers can be used repeatedly on new piles. However, any damaged or broken stickers should be discarded.

Even width stock should have a space between boards or planks not less than 20 percent of the width of the board. The boards in each succeeding layer should be placed directly over those below so that the spaces between boards will form uninterrupted vertical flues. The lateral spacing between boards or groups of boards, totaling 12 to 14 inches in width, should be at least 4 inches, so arranged as to form vertical flues in the pile. An alternate method with uneven width stock is to provide a tapering flue not less than 12 inches wide at the bottom and 6 inches at the top of the pile. With a tapering flue, allow at least 1 inch laterally between adjacent boards in each layer.

Each layer should consist of boards of the same thickness. Each succeeding layer should overhang the one below on the aisle end of the pile so that the pile pitches forward equal to about 1 inch per foot of height.

Each pile should have a roof equivalent to two layers of low-grade boards, those in the upper layer being staggered with respect to those of the lower. The roof should extend over the front and rear of the pile at least 1 foot and be raised above the top of the pile about 6 inches. The yard should be ditched to drain properly and kept free of weeds and debris.

The principles of proper piling as outlined are intended to offer:

(1) Adequate spaces for air movement through the pile both crosswise and vertically. Crosswise circulation occurs only when the wind is favorable, actually a small portion of the time. Evaporation absorbs heat, cooling the air, and as cold air is heavier than warm air, even the slight difference in temperature is enough to cause a down draft in the pile. The space provided below the pile allows this cool moist air to escape readily.

(2) The pile is given a slope, front to rear, so as to permit easy and positive drainage of any rain or snow water that may gain entrance to the pile.

(3) The stickers are placed close enough together so as to furnish adequate support against warping between supports. The amount of surface covered by the stickers is kept at a minimum so as to maintain uniform drying conditions throughout all parts of the boards. The stickers overhang the ends of the boards to create some shade against the sun and retard end checking.

In the case of species that are likely to check or honeycomb if dried too rapidly, the vertical spaces or air flues are reduced in width. In the case of species subject to stain and decay, these spaces may be increased in size.

Air Seasoning Sheds

Air seasoning under cover in properly designed open sheds have certain definite advantages over open yard piling, among which are: better protection of stock against sun and rain, material can be piled or removed during wet weather, and the protection offered reduces checking and splitting in refractory stock. Such a shed is described briefly in the section discussing the central supply yard. The method of piling is the same as that described for yard piling except that the foundation would be level, front to back, the pile would not pitch forward, and no roof would be required.

End Racking

Mahogany is a nonrefractory species, not inclined to warp or check and may be dried rapidly. Many producers end rack mahogany in place of flat piling since it may be dried rapidly by this method with low degrade. End racking as described in "The Air Seasoning of Wood" (see bibliography) is suggested for mahogany produced in Puerto Rico.

Dry Kiln

Dry kilns should be used for drying stock from the green condition, or that has not been thoroughly air-dried, also for any class of stock that

must be dried in a minimum time. The kiln should be of the forced circulation compartment type, having automatic temperature and humidity control and under the supervision of a trained kiln operator. The structure could be of wood or masonry, as desired. A kiln that would hold about 18,000 board feet should be about 51 feet long by 13 feet wide inside. The lumber should be end piled, the pile being 8 feet wide and 10 feet high over the truck. It would take about 4 to 5 days to dry air-dried 1-inch mahogany to an average of 9 percent moisture content, and up to 7 days for some of the other air-dried hardwoods. The kiln should dry about six charges of mahogany, or 108,000 board feet per month, or about four charges of slower drying species, or 72,000 board feet per month. The monthly capacity would be reduced to about one-third in each case if the stock was dried from the green condition. The actual kiln capacity required at the central supply yard can only be estimated when the volume of material to be handled, the species, initial moisture content, and similar factors are known. While one kiln of the size suggested would handle the estimated normal demand for mahogany, if thoroughly air-dried, it would require three kilns to handle the same volume from the green condition. If all of the lumber required to supply the estimates for the expanded program were to pass through the central yard and be kiln dried before delivery, a minimum of about seven kilns would be required for air-dried stock and more kilns would be required for stock having a higher initial moisture content.

Adequate track area should be provided for loading and storage of kiln trucks awaiting kiln space in addition to an unloading shed in front of the kilns. Transfer tracks are also needed to shift loaded kiln trucks at the kilns and to the cut-up plant. Steam would be required for heating and humidifying the kiln and the boiler capacity could be estimated on a basis that about 25 boiler horsepower is required per kiln for heating and humidifying.

Established dry kiln companies are prepared to furnish the plans for the kilns and all material, such as heating equipment, valves, traps automatic controllers, recording instruments, kiln cars, transfer cars, etc.

Conditioning or Storage Room

Kiln-dried stock, if held for any length of time before delivery or manufacture, should be stored, close piled, in an enclosed shed or room. Preferably such a room should be heated and the temperature maintained about 20° F. above the average outdoor temperature. Thoroughly air-dried stock, if open piled in such a room, will dry slowly and can be used without further drying in a kiln.

APPENDIX B

Timber Supply in the Dominican Republic and Haiti

Dominican Republic

Only 6 days were spent during this survey in the Dominican Republic. On the trip via airplane from Puerto Rico to Ciudad Trujillo, which is the capital of the Republic, a rather large body of virgin timber was observed in the eastern portion of the island. Considerable mahogany was scattered over this area. On another trip via airplane from Trujillo to Santiago, a large block of timber north of Trujillo was observed.

On a trip via automobile from Trujillo to S. Jose, 'de Ocoa, scattered mahogany trees were observed. Another trip via automobile was made to a small mahogany mill (small circular mill) located about 20 or 30 miles northeast of Trujillo. This mill was operated by an Hungarian refugee. He had about 30,000 feet of good mahogany logs on the millyard. In addition to this, he had several piles of mahogany logs and cants along the highway.

On the completion of field work in the Dominican Republic a trip was made via airplane from Trujillo to Port Au Prince, Haiti. This afforded an opportunity to observe the timber in the southern and western portions of the Republic. The various trips described above permitted the only opportunity to observe the stands of timber. From the foregoing, of course, it was impossible to determine the stands per acre, the quality of the timber, or the logging conditions.

Forest areas.--The forest areas of the Dominican Republic consist of three broad types: (1) the dense tropical hardwoods; (2) the open forest of the semiarid regions; and (3) the pine. The area of commercial forest land has been estimated at various times to vary from a minimum of 3 million acres to a maximum of over 8 million acres. Current estimates obtained from different individuals varied from a minimum of 5,000 square miles to a maximum of over 10,000 square miles. A report dated September 28, 1944, prepared by John Allen Bennett (see bibligraphy), shows that there is also a wide difference of opinion as to the total area of forest land. He estimated, as a conservative figure, that all land containing suitable trees of sufficient quality and quantity to justify commercial exploitation would not exceed 7,500 square miles, one-third of which he estimated had been cut. This estimate then, if adjusted to allow for the cutover areas, leaves a total net area of about 3,200,000 acres on which there is sufficient timber of desirable species to justify commercial exploitation.

"Forest Resources of the World" by Zon and Sparhawk, published in 1923, estimated the total area of forest land to be about 9,500,000 acres at that time. How much reduction there has been in the forest area since that date as the result of cutting, clearing, and fire, is not known. No attempt is made here to estimate the area of forest land, but it is known that there are still large blocks of virgin timber in the Dominican Republic that have apparently never been touched.

Forest volume.--Zon and Sparhawk in "Forest Resources of the World," 1923, estimated the pine at from 3 to 4 billion board feet and all hardwoods at 11 billion board feet, including all trees of merchantable size regardless of species. This estimate was not based on a forest survey, but was arrived at by using whatever information was available at that time. Since that date much timber has been cut and large volumes have probably been destroyed by fire and in clearing land for agricultural purposes.

Of the various individuals interviewed, not one would even hazard a guess as to the total volume of timber left. An estimate obtained from the office of the Secretary of Agriculture of the number of trees, but without information as to the size of the trees, quality, etc., indicates that there should be left at least 750 to 900 million board feet of pine, 150 to 200 million board feet of mahogany, and 450 to 600 million board feet of other good quality hardwoods, making a total of 1,350,000,000 to 1,700,000,000 board feet of sawlog size. Sufficient time was not available in the country to even give a rough approximation of the volume of timber of sawlogging size left, but it is believed that there is considerably more timber than indicated by the above totals.

One of the best informed operators that was interviewed stated that the present production of mahogany was about 2 million board feet, 1 million of which was produced by sawmills and 1 million by hand or whipsawing operations. This operator also claimed that if the necessary logging equipment, trucks, tires, and gas were made available that the production of mahogany could easily be doubled and maintained for a period of at least 20 years without exhausting the supply of the loggable material of this species. It is believed that two expert combination timber cruisers and logging engineers could make a reliable survey of the forest resources of the Dominican Republic in 4 to 6 months if planes and automobiles were made available as needed. If such a survey were made, the volume of timber and the feasibility and cost of operation could be definitely determined within reasonable limits. Because of the quantity of high-quality timber in the Dominican Republic, a reliable inventory of the forest resources, growth, and drain should be made. It is known that there are large volumes of high-grade material left, but any estimate that might be made based on only a cursory examination would be a wild guess having no practical value whatever.

Forest growth.--No attempt was made to estimate the annual growth. Determination of the annual growth for the pine species alone would require several months of field work. The annual growth of the hardwoods probably could not be determined, except by the establishment of permanent sample plots or by repeated reinventories of representative areas.

Forest drain.--The few reports and estimates that were available on total lumber production differed widely. None of them seemed reasonable. This is not a criticism of the production figures that were made available, but as they did not check with each other or with what many years experience with American forest drain figures would lead one to expect, it was decided to make a new estimate of lumber production.

For the year 1943, it is estimated that the total lumber production, including all species, ranged from 7 to 10 million board feet, or its equivalent. For the year 1944 there probably was a considerable decrease in production due largely to the difficulty of obtaining trucks, tires, and gas. It was evidently impossible to obtain reliable figures on the total forest drain during the short time available, but it is believed that the total annual drain, resulting from lumbering, logging, fuel wood and charcoal operations, fire, clearing for agriculture, and natural mortality in the stands of inaccessible virgin timber is somewhat in excess of the current annual growth.

Timber quality.--The Dominican mahogany has the reputation of being the finest quality in the world for certain purposes such as for the manufacture of novelties. Some of the leading novelty manufacturers claim that the best quality is found in Monti Cristi and Seibo. Mahogany grown in the Dominican Republic is too hard and heavy to satisfactorily meet the demands of some of the United States veneer operators and furniture manufacturers, but its grain and color are very attractive and it takes an excellent finish for novelties and furniture.

The largest stands of mahogany are reported to be in Barohona, Azua, Seibo, and adjacent lands. The quality of other hardwoods was not investigated.

The quality of the pine is considered very good, but it is rather heavy and tends to split when nailing. This species is a fine structural material and should be equal to the dense longleaf pine grown in the southern part of the United States.

Logging conditions.--Much of the remaining large areas of virgin timber is very rough, which will be difficult and expensive to log when measured by average American conditions. These areas are without railroad or highways, which probably explains why there is still a large volume of high-quality material left.

Logging methods are generally very primitive if measured by United States standards. Whipsawing and transportation of logs by ox cart for considerable distances, 6 to 10 miles, are common. There is one operator in the pine forest some 30 or 35 miles from Santiago that uses tractors and other modern equipment. The present primitive methods of operation are, no doubt, partly due to a shortage of trucks, gas, and tires. The situation in this respect was reported to be very critical.

General.--The Puerto Rico Development Company requested information as to whether or not a dependable supply of raw material, such as mahogany and other high-grade furniture woods, could be obtained from the timber stands of the Dominican Republic at reasonable prices. The Development Company is also anxious to know whether or not it would be more practical to ship logs and cants to Puerto Rico or do the manufacturing in the Dominican Republic and ship the plank and boards to Puerto Rico. If satisfactory arrangements can be made with the Government officials of the Dominican Republic to establish an operation there, and if satisfactory

guarantees of a dependable supply can be obtained, it is believed that it would be more efficient to manufacture the lumber there than to manufacture it in Puerto Rico. At least this phase of the problem should be carefully analyzed and its possibilities, advantages, and disadvantages carefully weighed before coming to any conclusion.

The development of an efficient logging and milling operation in any of the various large blocks of virgin timber in the Dominican Republic, which are now inaccessible, would require the expenditure of large sums of money for the construction of roads and the purchase of logging and milling equipment. Only by contacting the proper Government officials and ascertaining from them what arrangements can be made to obtain a dependable supply of raw material, and by making a careful study of the operating conditions and cost of operation by a competent logging engineer can the practicability or the impracticability of such a plan be determined. It is believed that the Puerto Rico Development Company would be justified in making this contact and study and in this way definitely determine whether or not this proposition has any real merit.

However, there are established operators who can furnish material as logs, cants, or lumber and who now own or have concessions involving large areas of forest lands. Unless the Puerto Rico Development Company is prepared to consider the rather extensive investments required it would appear more practical to buy direct from these operators. Moreover, Cuba is also a source of supply, now furnishing several times as much lumber to Puerto Rico as the Dominican Republic and similar problems would be involved regarding supplies from that country.

Current prices and their probable future trend were discussed with several of the leading operators and lumber dealers. There was a wide difference of opinion as to what the trend in prices would be after the war. Some thought that prices would remain about at the current level, or even go higher for several years, while others thought that there would be a very material drop in prices shortly after the war ends. The demand for all grades of lumber will undoubtedly be so strong after the war, and particularly for high-quality woods, that it is reasonable to expect prices to remain at a high level or even some increase in prices instead of a reduction, unless adequate price control measures are put into effect by the leading timber-producing countries, or unless satisfactory substitutes are produced at reasonable prices. The price of lumber increased after World War I and remained at a high level for several years. It may happen after World War II if proper control measures are not put into effect.

Haiti

Approximately 6 days were spent in Haiti, during which time the leading novelty and furniture manufacturers were interviewed and a study made of the only logging and sawmill operation of any size in the entire country. This operation is conducted by the SHADA Corporation and is located in the pine type about 50 miles out of Port au Prince. This company operates two circular mills and can cut from 15 to 20 thousand feet per day, depending on whether they cut inch boards or timbers.

Timber supplies.--The novelty and furniture manufacturers stated that they were unable to obtain a sufficient volume of suitable native hardwoods to meet their requirements. It was reported that the Haitian Government is taking the necessary steps to prohibit the exportation of mahogany, except in the manufactured form, such as novelties and furniture. Therefore, it is certain that the Puerto Rico Development Company cannot obtain any appreciable supply of hardwoods from Haiti.

An airplane trip over part of the hardwood areas did not reveal any appreciable volume of desirable hardwoods on loggable areas. A considerable portion of the pine areas, observed from the air, would run 4,000 board feet or more per acre. There is probably a total of 250 to 300 million board feet of pine in Haiti and the pine is of good quality. It produces a higher percentage of No. 1 common and better lumber than the stands of southern pine in the United States. It is very heavy and produces fine structural timbers, but it is not so satisfactory for shop work as some of the softer textured species of pine.

The pine operation conducted by the SHADA Corporation is efficiently managed. Under the present form of forest management, cutting practices, and protection measures adopted, this company should be able to cut 5 to 8 million board feet per year on a sustained yield basis. They are now cutting about 4 million board feet per year. This company can probably furnish Puerto Rico a small volume of pine lumber per year. The lumber is unusually well manufactured and satisfactorily piled for air drying. Because of the high type of manufacture and good quality material produced, the lumber from the SHADA Corporation's operation should be entirely satisfactory in all cases where this character of pine meets the requirements of the user. No attempt was made to estimate the volume of hardwoods in Haiti.

APPENDIX C

Review of the Termite Problem

In the tropics, wood and wood products are subject to certain destructive agencies not found in more temperate climates. Prominent among these in the West Indies, central and northern portions of South America is the dry wood termite, Cryptoterines brevis Walker, "polilla de madera," or simply "polilla" in most of the Spanish speaking countries. This termite is particularly plentiful in Puerto Rico where it causes an enormous amount of damage to wood structures and furniture and other wood products. It is selective in the type of wood it prefers, some species being practically immune to attack, but as these species are few in number, scarce and expensive, species lacking immunity are used quite generally both in buildings and in furniture.

The better grades of furniture are of course made of the highly immune species and to obtain full immunity, all parts of a unit must be of such material, a factor that adds substantially to the total cost of the finished article. In a dresser, for example, it is customary to use comparatively inexpensive species for drawer sides and backs and certain other concealed parts, and to use the expensive material for top, front, and sides. Such construction in the tropics is not satisfactory, however, since those parts which are not immune will be attacked by termites. Face veneers of resistive species will not protect the core stock if it is a nonresistive species. Hence, it is customary in Puerto Rico to use the highly resistive species for all parts of a piece of better grade furniture, and to use solid wood in preference to veneered wood.

There is some local prejudice in Puerto Rico against the use of kiln-dried lumber on the basis that such material is more liable to termite attack than is air-dried lumber. There is probably no data to substantiate or refute this impression, but logically, there appears to be no reason why kiln-dried stock should be more susceptible to termite attack than is air-dried stock. Kiln drying is merely air drying under conditions where somewhat higher temperatures are used, than are attained in normal air drying. The temperatures used in normal kiln operations are not high enough, however, to affect the properties of wood which make it unpalatable to termites.

Wolcott (see bibliography) has compared the resistance of various species to the attack of this termite and has found a number of resistive species. Unfortunately some of these species are unsuited for furniture use and some are extremely scarce. Mahogany is a favorite furniture wood, not only because of its resistance to termites, but it is strong and of medium weight, easy to season, works well with tools, takes an excellent finish, holds its shape well in service, and is reasonably easy to obtain. Probably no other species enjoys as many of these properties and qualifications in Puerto Rico. Cedro, or West Indian cedar, is also highly resistant and, though not so plentiful as mahogany, is used to considerable extent in the furniture trade. Of the domestic species used in making

furniture, the principal ones are guaraguao and capá prieto, both of which have a high degree of resistance, and jaguilla and laurel sabino, which are classed as susceptible. Black walnut, a premier furniture wood, is also classed as highly resistant. Many other species found in the West Indian islands and in Central and South America are also classed as highly resistant species, some of which are suitable for furniture.

The sapwood of most species is considered susceptible and should not be used in combination with the heartwood of resistant species. Most of the species used for furniture in the United States are susceptible, such as the oaks, maple, birch, poplar, and sweetgum. It is possible, however, to use susceptible species by affording them either mechanical protection or chemical treatment that makes the wood unpalatable.

Mechanical protection can be obtained by suitable varnish or paint coatings that cover all surfaces. The termites do not enter the wood through surfaces that have such protection, but search for some surface or joint where bare wood is exposed. Adequate protection means, of course, that it is necessary to coat not only the exposed areas usually finished for sake of appearance, but also those parts normally concealed from view, such as the backs, inside and outside of drawers, all inside surfaces of dressers and cabinets, and even the bottoms of chair legs. In the latter case, "domes" might also be used to prevent wearing off the protective coating. The full effectiveness of mechanical protection is jeopardized if for any reason some part is left uncoated or if, due to shrinkage, joints open up, or where the coating is broken through mechanical wear or by injury.

The wood may be treated with a toxic solution that will afford protection indefinitely in the case of furniture and similar items not exposed to repeated wetting. There are probably a number of toxic materials that might be used, some of which stain the wood, others may be hazardous to handle. One which is relatively free from these disadvantages would be a solution of 5 percent by weight of highly chlorinated phenols, such as pentachlorophenol, and resins or water repellents in volatile petroleum solvents, such as mineral spirits. Such solutions are available commercially. For treatment, the wood parts would be shaped ready for assembly, then dipped in the solution for 1 minute, removed, dried, and assembled. No cutting or fitting should be allowed after dipping and no more than light sanding without retreating the part that had been cut. In some cases, it might be practicable to dip the completed article.

APPENDIX D

Dimension Stock

Ordinarily lumber is produced in the shape of boards and planks and for most factory uses, these boards and planks are resawn or cut up into smaller sizes for use in the ultimate product. Such small clear pieces are called dimension stock. In the making of chairs, for example, all parts are of comparatively small dimension when ready to assemble, but usually they have been cut out of full-sized boards or planks. In chair manufacture, a large number of chairs may be made at one time of the same design and shape, which means that a large number of pieces of identical size and shape are required. In producing these pieces from boards a certain amount of waste in making the cuttings is inevitable, the yield in clear cuttings often being only 50 to 60 percent of the original footage in the upper grades of lumber and less in the lower grades. The same problem of cutting applies to the manufacture of most furniture items, such as tables, beds, dressers, etc., and also to planing mill products, such as doors, windows, parquetry flooring, and some items of interior trim. It applies to the box and container industry in producing box shooks and to most of the other woodworking industries to some degree.

If these standard sized cuttings were produced at the central supply yard, a number of definite advantages accrue.

In making cuttings for tables and beds where relatively long lengths are required, there are numerous pieces that are left as waste that would produce short or narrow cuttings suitable for use in other products. Manufacturers of other products also find that they have waste of useful size that they cannot use advantageously. When cut at a mill supplying a full line of cuttings in the form of dimension stock items, each piece of lumber can be cut to produce its maximum yield of clear dimension stock according to the requirements of the various manufacturers. Dimension stock can be produced from material that often would be a waste product and from lower grade items having low market value.

There is an important economy in transportation since it is not necessary to ship the portion that would be waste in producing the cuttings from lumber at the plant of the ultimate consumer. Even the labor handling costs are reduced materially because of the reduction in volume and weight. Storage space required is much less for dimension stock than for lumber.

In many respects, dimension stock production is more promising under conditions as they pertain to Puerto Rico than in the United States, particularly as it applies to material produced locally and imported from the Dominican Republic and Cuba. Difficult logging conditions encourage the extraction of short and random length logs. The high value of certain species, particularly mahogany, encourages the extraction also of crooked logs, deeply fluted logs, and even defective logs that will produce some good material. Lumber produced from such logs will naturally be random

length and width with a high percentage of short boards and in making cuttings, the ultimate consumer has more waste than would develop from longer even length boards. The dimension stock producer can cut up such stock more efficiently into sizes that can be used than can be done in a furniture shop having a more limited number of cutting sizes. In Puerto Rico, the novelty trade can absorb some of the small pieces of mahogany that otherwise would be waste.

There are, of course, certain problems in producing dimension stock that must be considered and overcome for successful operation. Seasoning, for example, has been one of the big stumbling blocks in dimension stock production. When dimension stock is cut from green material, it is more likely to warp and twist during subsequent seasoning than when seasoned in the board form. When possible it is good practice to season the stock in the board or plank form before working up into dimension stock. The handling costs are also materially greater than for an equal footage of material in board form. The requirements of the various consumers may mean a considerable number of standard sizes would be required. Production efficiency and quick handling of stock may mean that the number of sizes produced be kept at a minimum, making only those standard items in greatest demand.

Methods of handling in the production plant, bundling devices, and other labor-saving methods must be carefully worked out for all operations. The potential market must be assured and suitable agreements worked out with the consumers regarding the sizes, minimum overrun in dimensions permitted for working and machining, grades, defects permitted, and other similar factors. Dimension stock usually commands a price of about double that of the same footage of lumber.

Some manufacturers cannot use dimension stock exclusively and would require a certain amount of supplementary lumber. Presumably, the central yard will import material as logs, squares, cants, and lumber. Distribution to the subscribers can be made both as lumber and dimension stock. The maximum yield in footage would be obtained by importing logs and doing all converting at the central yard. In sawing logs, slab cuts would be thin and often short of the full length of the log. The first cut could be wasted if necessary, but all later cuts would be left with barky edges untrimmed for making dimension stock.

The equipment and machinery required for producing dimension stock has been listed.

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A young plantation in the Luquillo National Forest,
Puerto Rico.

Logging road built in the Luquillo National Forest, Puerto Rico, to take out tabonuco for defense work.

Sawing tabonuco by hand in the Luquillo National Forest, Puerto Rico. Logs are converted to planks or small squares to facilitate removal from the forest.

Ox yokes are made by hand in the forests of Puerto Rico.

Sacks of charcoal ready to be hauled by truck to the market in Puerto Rico.

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Planks produced locally in Puerto Rico are usually stored under cover in an open shed. Better piling methods would mean better seasoning and less stain and decay while in storage.

Whipsawed squares and planks at a furniture plant in Puerto Rico. Such material is usually resawed into lumber with circular saws.

Four teams of oxen were required to haul out a few logs scaling 420 board feet. Only one round trip is made each day. Dominican Republic.

Log yard at sawmill in the Dominican Republic.
Material may be brought out as logs or hewn squares.
Some material is very crooked, some logs are
deeply fluted.

Mahogany in the Dominican Republic is valuable and it pays to bring out small crooked logs.

A small circular sawmill in the Dominican Republic. This mill cuts about 1,500 board feet of mahogany per day. There were about 30,000 board feet of logs in the yard.

Sawn mahogany lumber at a mill in the Dominican Republic. Quantities of good dimension stock can be produced from the low grade boards.

Log on a frame ready to saw. It is estimated that one-half of the mahogany produced in the Dominican Republic is cut on such frames.

Whipsawed mahogany in the Dominican Republic.
Much of the material observed was equal
to that produced in the circular sawmills.

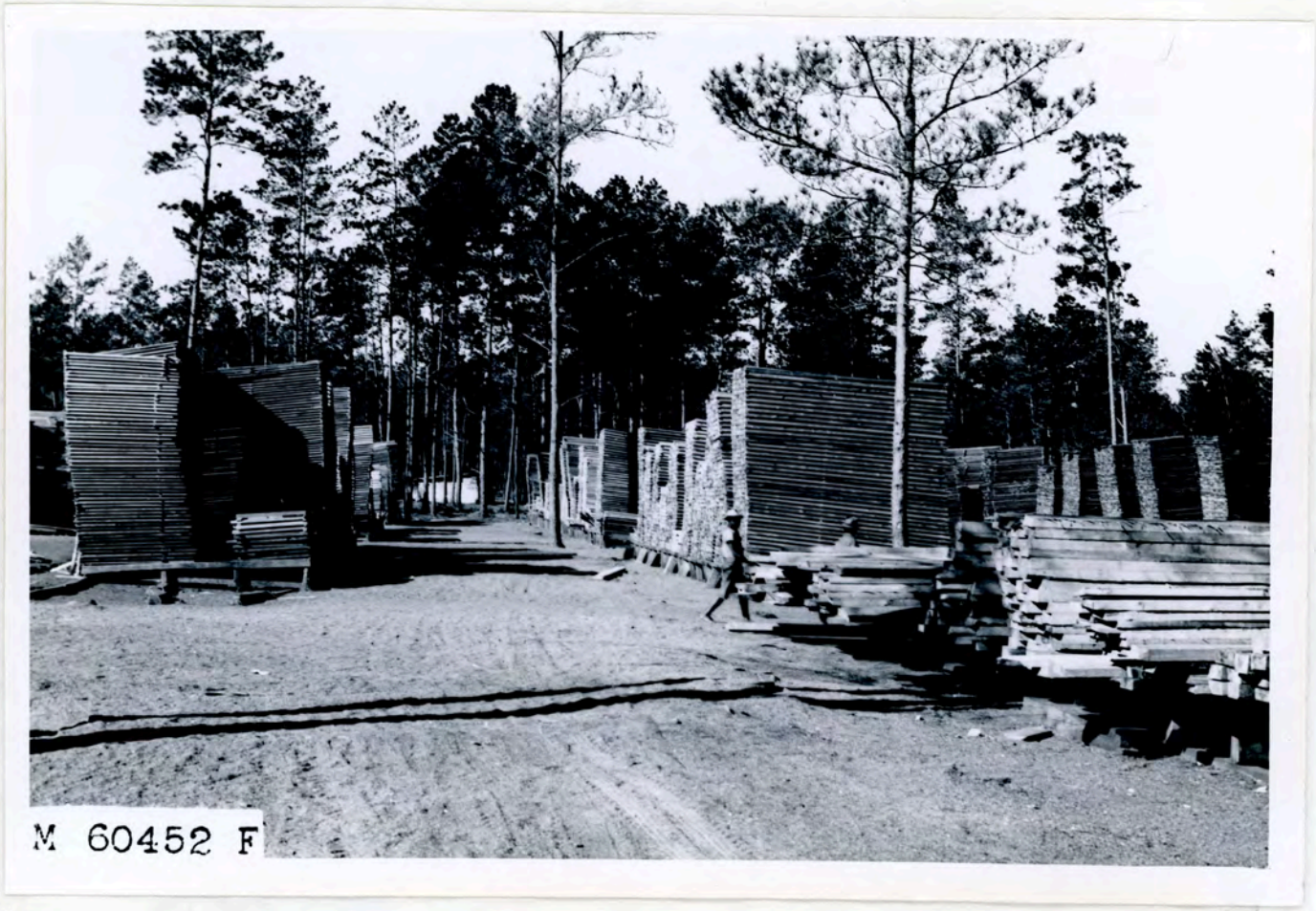
Mahogany bolts used in making wood novelties
in Haiti.

The whipsawed lumber in Haiti is liable to be poorly sawn and of unequal thickness though often cut from comparatively large logs.

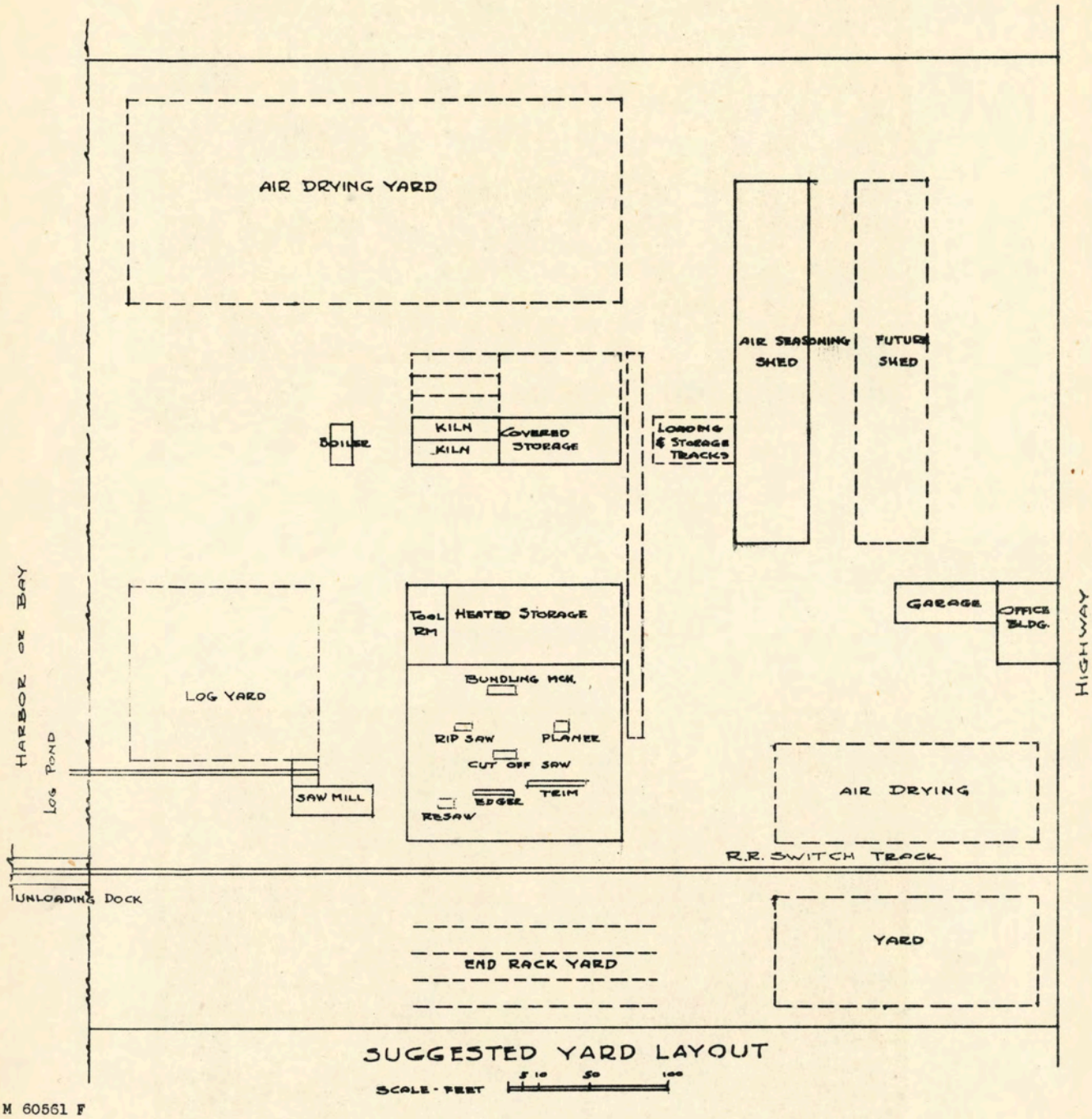
Whipsawed mahogany lumber, all thicknesses and lengths. Used in production of novelties in Haiti.

A smoke kiln used to season pine in Haiti.

Cutting pine logs in Haiti.



Seasoning yard at a pine sawmill in Haiti.


AIR DRYING YARD
AIR SEASONING SHED
FUTURE SHED
KILN
KILN
COVERED STORAGE
BOILER
LOADING & STORAGE TRACKS
HARBOR OF BAY
LOG POND
LOG YARD
TOOL RM
HEATED STORAGE
BUNDLING MCH.
RIP SAW
PLANER
CUT OFF SAW
TRIM
EDGER
RESAW
SAW MILL
GARAGE
OFFICE BLDG.
HIGHWAY
AIR DRYING
R.R. SWITCH TRACK
UNLOADING DOCK
END RACK YARD
YARD
SUGGESTED YARD LAYOUT
SCALE - FEET
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